

Analysis of Comparative Methods for Edge Enhancement Filters-II

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ABSTRACT

Edge enhancement filters are used to sharpen the intensity differences in the images. There exist certain methods, which are used to diagnose the basis of Edge Enhancement Filter. Each method uniquely evaluates the potentiality of edge enhancement filter. It is significant to distinguish these methods to realize which method is efficient. Analysis is made on the functionality of each method by comparing behavioral aspects of each method.

Keywords: Convolution, Edge Enhancement Filter, Pixel neighborhood, Spatial Domain, Threshold.

I. INTRODUCTION

Processing an image to enhance certain features, result in enhancement of that image [1]. Edges are one among the certain features which can be enhanced to improve edge information [7]. To perform enhancement it is necessary to transform the original image to desirable form [3]. This transformation is done with filters [5]. So the filter used for edge enhancement performs transformation mechanism, which is dependent on the filter and the original image [3].

$$G(x, y) = T [F(x, y)]$$

G is the transformed image and F is the original image and T is the transformation mechanism used on respective pixel positions x and y.

The transformation would direct towards the specific requirement to process the image. Edge information representation can be done using a specified transformation on the image. There exist certain methods to analyze the efficiency in this transformation operation i.e. these methods describes how well the transformation has been done. These methods are compared against each other and finally the best method is identified on the basis of their working ability.

II. BACKGROUND

Edge information that is present initially in the original image may or may not be highlighted by Edge Enhancement Filter [6]. As edges are represented according to their pixel positions, number of edge Pixels are suitable to predict whether or not desirable edge pixels have been identified [7].

Derivation of a probability measure determining how many edges have been identified from the actual number of edges is described below.

Let P denotes the probability of identifying edges from image S, then

$P = (\text{number of edges identified}) / (\text{initial number of edges})$

P determines a probabilistic measure to study the behavior of Edge Enhancement Filter.

III. ANALYSIS OF COMPARISON METHODS FOR EDGE ENHANCEMENT FILTER

The Four methods are namely:

- Mean
- Edge Based Similarity
- Correlation quality
- Modified Euclidean distance

We would discuss each method and will see how they are helpful to study the behavior of edge enhancement filters.

3.1 Mean

Denoted as 'μ', where $\mu_x = (1/n) * \sum T$, n is dimensionality of image. μ_x is calculated for each image 'T', which is obtained by above threshold values.

3.2 Edge Based Similarity

In this method, we are going to calculate the variance values of source image respective to image obtained for each threshold value.

It is denoted as $\sigma_{xy} = 1/n \sum ((x_i - \mu_x) (y_i - \mu_y))^{1/2}$, where

n is the dimensionality

x_i is the source image

μ_x is the mean of the source image

y_i is the image obtained by applying corresponding threshold value

μ_y is the mean of the image obtained by applying corresponding threshold value

3.3 Correlation quality

Another approach to assess the behavior aspect of edge enhancement filters. This method also considers both the source image and the image obtained from corresponding filter. Correlation quality is given by,

$\sum S_{i,j} * T_{i,j} / \sum S_{i,j}$, Where S denotes the source image and T denotes the corresponding image obtained for each threshold value.

3.4 Modified Euclidean Distance

This method works similar to Euclidean distance approach to measure similarity between 2 objects. The modified Euclidean distance measure is given by:

$\sum(S^2-T^2)/MN$, where S is the source image, T is the image obtained after applying threshold, M and N are the number of row and cols.

By using the above approach, we would measure the similarity between every T image with the S image.

IV RESULTS AND ANALYSIS

The above discussed methods are illustrated by considering a sample image, on which both Laplacian and Sobel filters are applied individually to derive comparative analysis.



Fig. 5

On applying certain threshold values after applying Laplacian Filter on Fig. 5, will result as follows.



Fig. 6.Threshold=125



Fig. 7.Threshold=128



Fig. 8.Threshold=130

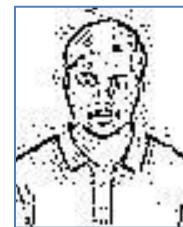


Fig. 9.Threshold=132

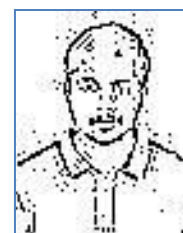


Fig. 10.Threshold=134



Fig. 11.Threshold=140

The results obtained after applying discussed methods on Laplacian filtered threshold outputs are tabulated as follows:

TABLE 1

Results Obtained for the three methods on Laplacian filtered outputs shown in Fig. 6 – Fig. 11

| Thresh old | 125 | 128 | 130 | 132 | 134 | 140 |
|-----------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Mean | 33.19 | 25.01 | 21.33 | 19.26 | 16.79 | 12.17 |
| Edge based similarity | 15803 .15 | 14806 .52 | 14346 .50 | 14082 .74 | 13761 .73 | 12143 .68 |
| Correlation quality | 0.02 | 0.014 | 0.012 | 0.01 | 0.009 | 0.006 |
| Modified Euclidean Distance | 12018 .86 | 9494. 45 | 8333. 04 | 7668. 70 | 6862. 25 | 5310. 04 |

These tabulated values for each threshold value on Fig.5 are represented graphically as follows. X-values represent the threshold values and Y-values represent the corresponding method value.

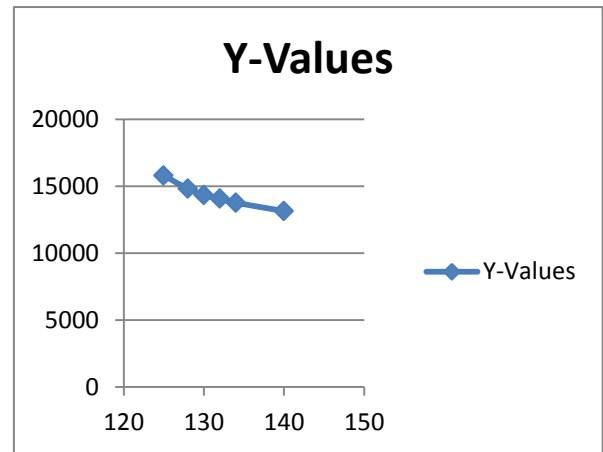


Fig. 13.Edge Based Similarity

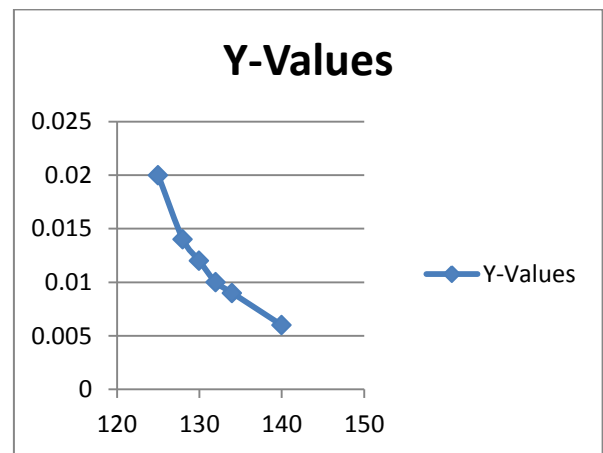


Fig. 14. Correlation Quality

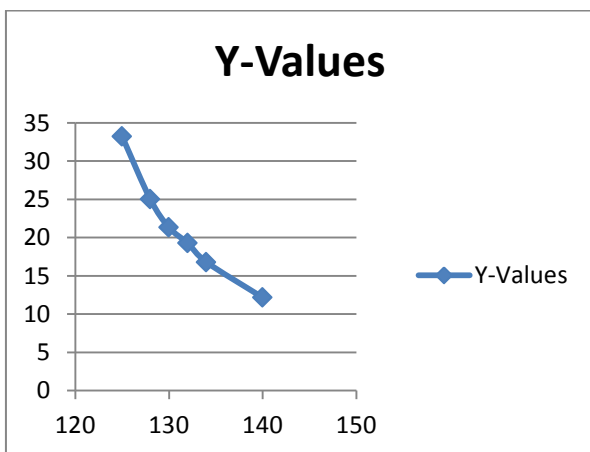


Fig. 12. Mean

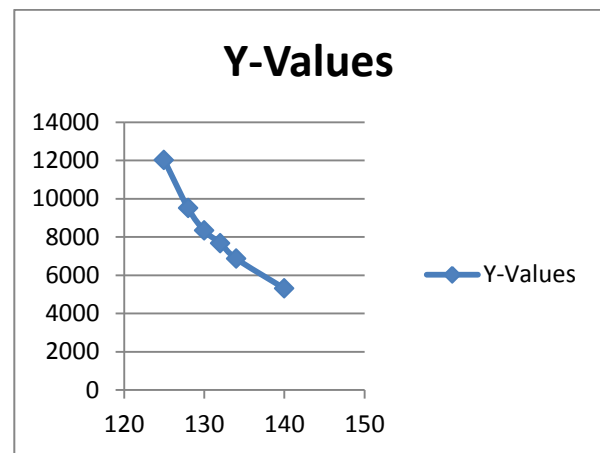


Fig. 15. Modified Euclidean Distance

On applying certain threshold values after applying Sobel Filter on Fig. 5, will result as follows.



Fig. 16.Threshold=125



Fig. 21.Threshold=137

The results obtained after applying discussed methods on Sobel filtered threshold outputs are tabulated as follows:

TABLE 2

Results Obtained for the three methods on Sobel filtered outputs shown in Fig. 16 – Fig. 21

| Thresh old | 125 | 127 | 130 | 133 | 135 | 137 |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Mean | 30.48 | 24.02 | 19.60 | 16.66 | 14.77 | 13.34 |
| Edge based similarity | 15485 .04 | 14699 .46 | 14147 .60 | 13771 .62 | 13523 .50 | 13333 .48 |
| Correlation quality | 0.023 | 0.018 | 0.014 | 0.012 | 0.011 | 0.010 |
| Modified Euclidean Distance | 11186 .35 | 9204 .09 | 7813 .50 | 6868 .71 | 6246 .46 | 5769 .58 |



Fig. 17.Threshold=127



Fig. 18.Threshold=130



Fig. 19.Threshold=133



Fig. 20.Threshold=135

These tabulated values for each threshold value on Fig. 5 are represented graphically as follows. X-values represent the threshold values and Y-values represent the corresponding method value.

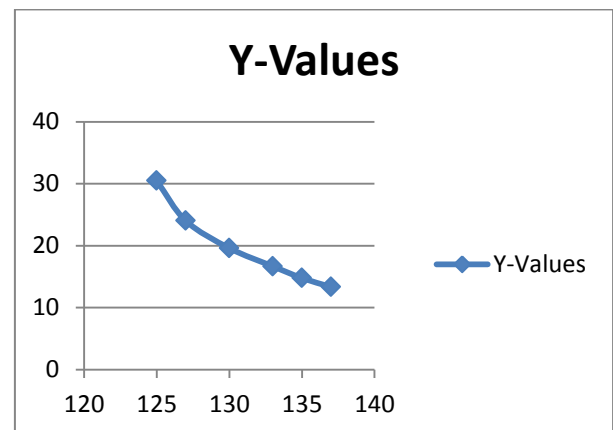


Fig. 22.Mean

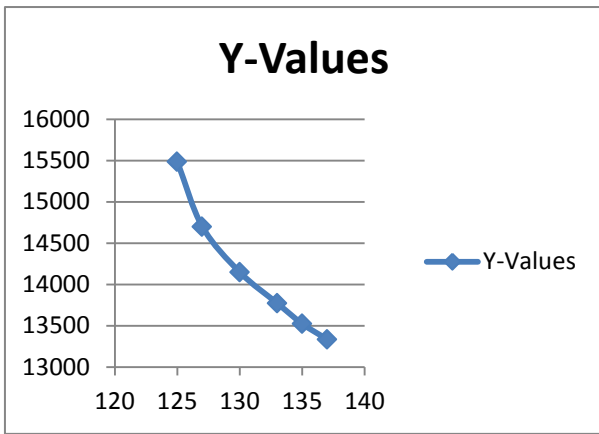


Fig. 23.Edge Based Similarity

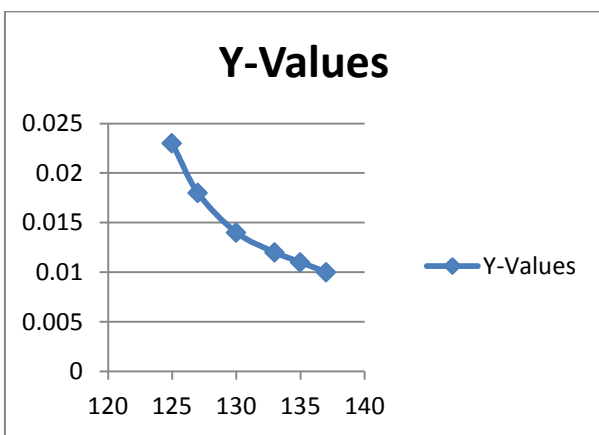


Fig. 24. Correlation Quality

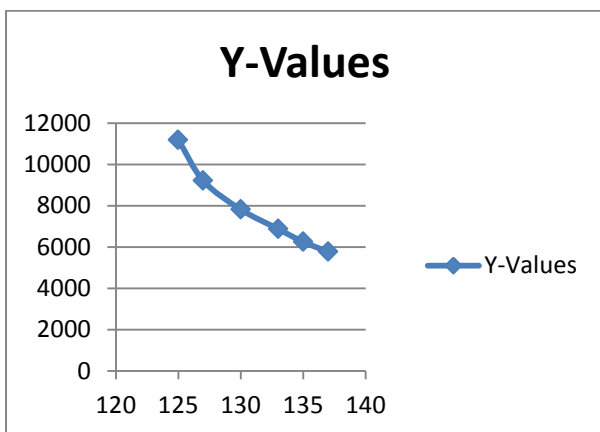


Fig. 25. Modified Euclidean Distance

V. CONCLUSION

Analysis on the results obtained by each method is made by considering the threshold outputs of both Laplacian and Sobel filters.

5.1 Laplacian

The effectiveness of each method is determined by comparing the results obtained by respective method on every threshold output obtained using Laplacian filter. The following observations are made:

- a) On comparing threshold outputs 125 and 128, many edges got reduced indicating a difference in the number of edges.
- b) On comparing threshold outputs 128 and 130, the change is negligible i.e. almost similar.
- c) On comparing threshold outputs 130 and 132, there is no much difference.
- d) On comparing threshold outputs 134 and 140, the difference is even higher than the previous differences.

Mean:

- This method identifies the changes almost similarly as mentioned in the observations ‘a’, ‘b’ and ‘c’. It also identifies the major change as mentioned in observation ‘d’, but not exactly.

Edge Based Similarity:

- This method exactly identifies the changes as mentioned in the above observations ‘a’, ‘b’ and ‘c’, but it represents the higher change with a smaller variation.

Correlation Quality:

- This method is desirable according to observations ‘a’, ‘b’ and ‘c’. But it could not be able to represent the major differences as specified in observation ‘d’.

Modified Euclidean Distance:

- This method recognizes the exact major differences as mentioned in the above observations but not to proper extent.

5.2 Sobel

Analysis on the values obtained for each method is made by considering Sobel outputs as follows:

- a) On comparing threshold outputs 125 and 127, there is a decrease in the number of the edges.

- b) On comparing threshold outputs 127 and 130, there is a higher difference compared to the previous value.
- c) On comparing threshold outputs 133 and 135, there is a difference in the number of edges but the difference is lesser than the previous difference.
- d) On comparing threshold outputs 135 and 137, there is change that is nearly similar to the previous difference.

Mean:

- This method also justifies the observations 'c' and 'd' but not observation 'b'.

Edge Based Similarity:

- This method nearly reaches the statement made in the above observations.

Correlation Quality:

- This method could be able to justify the observations made in 'b' and both 'c' and 'd'.

Modified Euclidean Distance:

- This method behaves almost similar to the Correlation quality but not satisfying the above stated observations.

Observing the values obtained by each method, the order for efficiency among these methods is given in decreasing order as follows.

Mean>Edge Based Similarity>Modified Euclidean Distance> Correlation quality.

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